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On the Theory of M. Foucault's Gyroscope Experiments.

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The remarkable experiments of M. Foucault for exhibiting both a new direct proof of the earth's rotation, and the indirect effect of it in the "orientation" of the axis of a disk influenced only by mechanical rotation, have excited great interest; and thus an attempt to elucidate and simplify the *theory* of them may not be regarded as useless, especially as that *theory* has been found in some degree obscure and complex, more particularly as treated on the principle of M. Poinsot's theory of "couples." See *Comptes Rendus*, tom. xxxv.

The apparatus (or "gyroscope") consists essentially of a circular metallic disk, heavily loaded round its circumference, rotating on an axis, whose ends turn with the most perfect freedom in the opposite points of a brass circle, itself supported at the intervening opposite points on pivots in a second brass circle, suspended in a vertical plane by a thread without torsion at the top, and resting on a pivot at the bottom, both attached to an outer vertical frame. The motion of either of these circles can be suppressed, so that the axis of the disk can move either in altitude or in azimuth only, or freely in both (see fig. 1).

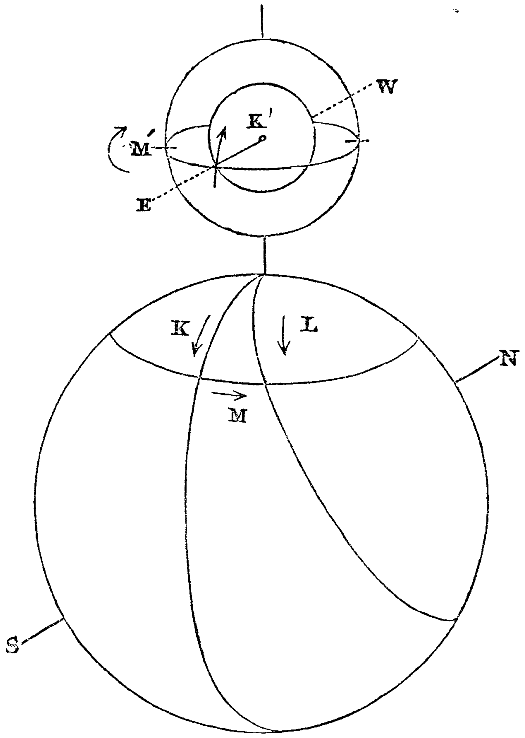

Fig. 1.

In these experiments the most material mechanical condition is what M. Foucault terms "the constancy of the plane of rotation,"—that is, the loaded disk having an immense rotatory velocity communicated to it by the action of a train of wheels before it is placed on its pivots, retains, by virtue of its great acquired momentum, this motion *in the plane in which it was communicated*, independently of gravitation or any other circumstances,—so much so, as to resist with considerable force any attempt to place it in a different position.

In the following brief explanation it may be necessary to premise,—

1. The principle of the composition of rotatory motions, or that if a body be rotating about a given axis, and a tendency to rotate about another axis at the same time be given to it, the two rotations compounded will give a resultant rotation about a new axis inclined in a direction between the two former, whose position is determined by the well-known theorem, for which see Mr. Airy's tract on Precession.

2. The inverse principle of the resolution of rotatory motion, as applied by Euler to the rotation of the earth at any point on its surface, where the whole rotation being in a plane passing through the parallel of latitude of the place (which, for brevity, I call "the plane of latitude"), and the rotation for a given time (L) in that plane, it is resolved into two components, one in a circle passing through the place perpendicular to the meridian (K), the other in a circle (M) cutting the last at right angles, and whose centre is the place of observation. It is easily seen that the component (K) is *initially* proportional to the *cosine*, and (M) to the *sine* of the latitude (see fig. 1).

3. In any composition of forces p and q, of which r is the resultant, if the same action be repeated with p and r as components, the new resultant r_1 will lie between p and r. If it be again repeated r_2 will lie between p and r_1, and so on, till ultimately r_∞ will coincide with p.

Case I.—The disk rotates, being in perfect equilibrium, and free to move both in altitude and azimuth (see fig. 1).

Let us suppose the disk to have its axis in the first instance horizontal, and pointing east and west.

Then the rotation of the earth carries it along with the apparatus, and, if at rest, would cause it to incline towards the east in the plane of the latitude.

But, owing to "the constancy of the plane of rotation" the disk tends to retain parallelism to its original plane; and being perfectly free to move with respect to the apparatus, and wholly free from the influence of gravitation, it has a relative apparent motion equal and opposite to that of the earth in the plane of the latitude (L), the components of which in altitude (K′) and in azimuth (M′) are exhibited by the moveable circles of the apparatus respectively.

The motion in altitude would be inconvenient to observe, as it changes its plane continually; that in azimuth is easily observed, by means of a horizontal microscope with focal wires, directed to a small graduated scale on the edge of the vertical circle.

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These motions continue with the rotation of the earth as long as the rotation of the disk is kept up: and the *rate* of the azimuthal motion is easily seen to be proportional to the *sine of the latitude* of the place, as in the case of the free pendulum.

Case II.—The disk rotates, having its axis horizontal, and free to move only in azimuth.

Let the plane of the disk (d) be at first parallel to the meridian (see fig. 2), or have its axis pointed E. and W.

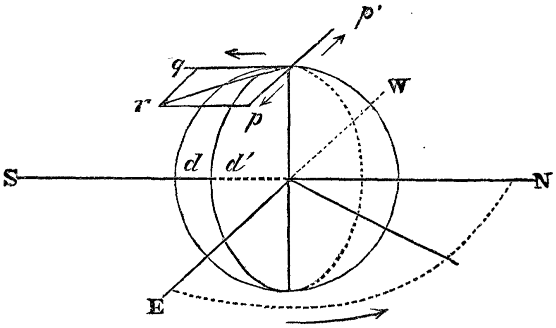

Fig. 2.

Then the constancy of the plane of rotation opposing the effect of the earth's rotation in the plane of the latitude tends to make the disk incline in that plane from east to west, initially in the direction (p') of the tangent to the arc which its upper extremity would describe. But the vertical diameter of the disk being fixed by the apparatus relatively to the earth, offers an equal and opposite reaction (p).

This has to be compounded with the rotatory motion of the disk (q), (suppose towards the south, at the upper part), which will give a resultant rotation (r) in a plane between the two; or the disk will take a new position (d'), to which (r) is a tangent, in a plane inclined to that of the meridian, its axis turning in azimuth from east towards north.

In this new position the same action will be repeated, the components being now (p) and (r), and the new resultant (r_1) will place the axis between the former position and the north, and so on, till it ultimately points to the north, coinciding with the meridian, in which position it will continue.

If the rotation had been the opposite way it is easily seen; a similar construction would give the disk turning from north towards east. And in either case, when in the final position, the rotation will be in the same direction as that of the earth.

Case III.—The disk rotates, having its axis free to move *only* in altitude, and in the plane of the meridian.

In the first instance, suppose the axis horizontal, and the rotation towards the east at the upper part (see fig. 3).

The disk, if free, would have an apparent motion opposite to that of the earth, or the eastern extremity of its horizontal diameter

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would have a motion upwards in the plane of the latitude, whose initial direction (p^1) is the tangent of the arc it would describe.

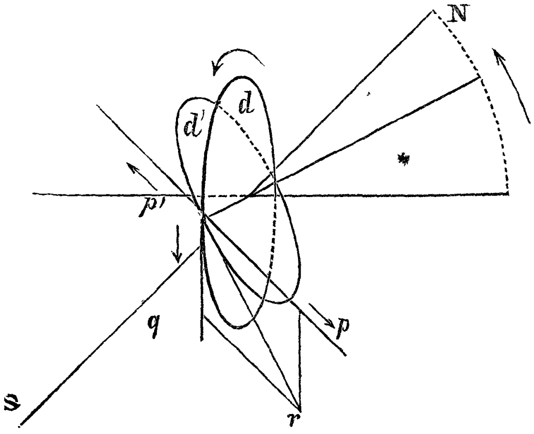

Fig. 3.

But this motion is counteracted by the apparatus giving an equal and opposite reaction downwards (p). This, combined with the rotation (q), gives a resultant (r) between them, in consequence of which the disk (d) takes a new inclination (d'), its axis ascending at the north end, till ultimately it becomes parallel to the axis of the earth, when the rotation of the disk will be in the same direction as that of the earth. If it had been originally rotating in the opposite direction, it is easily seen in the same way that it would come round to the same position.

Report of the Director of the Imperial Observatory of Paris on a Plan for Improving the Organisation of that Establishment.

In accordance with a decree of the Government, the Director of the Imperial Observatory of Paris has recently drawn up a Report on a proposed plan of operations to be pursued at that establishment with the view of placing it on a level with the other Observatories of the first class in Europe. The details of the plan are embodied in a Report recently addressed to the Emperor by M. Fortoul, Secretary of State for the Department of Public Instruction. The contents of this Report, of which the following is the substance, are classed under seven distinct heads.

1. *Meridian Observations.* — Operations of this kind were long imperfectly attended to in France. The first transit instrument was erected at the Paris Observatory only in the year 1800. Since that time foreign establishments have accomplished from year to year considerable progress. In order that the Observatory of Paris may maintain itself on a level with them, it is indispensable that an improvement be effected in the instruments available for that purpose, as well in regard to optical power as in